USING COMPUTERS TO PREPARE FOR DISEASE OUTBREAKS

Progress from the National Institute of General Medical Sciences

PREDICTING THE POTENTIAL SPREAD OF AN INFECTIOUS DISEASE requires much more than simply connecting cities on a map. Researchers must take into account many factors about the disease and the affected population. With the help of computers, a scientific network now is using this information to simulate how infectious diseases emerge and spread through communities, countries, and even continents. The results already are helping health officials and policymakers prepare for infectious disease outbreaks.

MIDAS
Models of Infectious Disease Agent Study

WHY USE COMPUTERS TO STUDY DISEASE?

Computers serve as virtual laboratories where researchers can study problems not easily examined in real life. The experiments consist of computer simulations—representations of actual communities based on demographic and transportation information. In these simulated environments, the researchers can introduce an infectious agent with certain characteristics and then watch it spread.

Scientists create these simulations with the help of customized programs called computational models. Different models address different questions. The ones frequently used for studying diseases are agent-based, which model how a virtual person could behave in the simulated community. Each individual has a chance of catching or spreading an infection through encounters with others at home, work, school, and elsewhere.

In constructing these models, the scientists start with assumptions about how people interact and how infectious agents spread. Onto this, they add known or estimated information about actual communities and the infectious agent that might emerge there. They can also introduce and evaluate the effectiveness of different interventions, such as vaccination or quarantine. Researchers can modify the models to simulate different situations, such as a more urban community or a more contagious virus. Scientists and policymakers analyze and compare the outcomes to better understand how an outbreak occurs and spreads.

Because the models are very complex, researchers use high-performance computers to generate the simulations. The models may run for weeks at a time, producing millions of different possible outcomes. But no single set of results or single model can predict exactly what will happen. As a result, scientists often ask different models the same questions. When different models yield similar results, researchers have more confidence in the predictions.

WHO BUILDS THE MODELS?

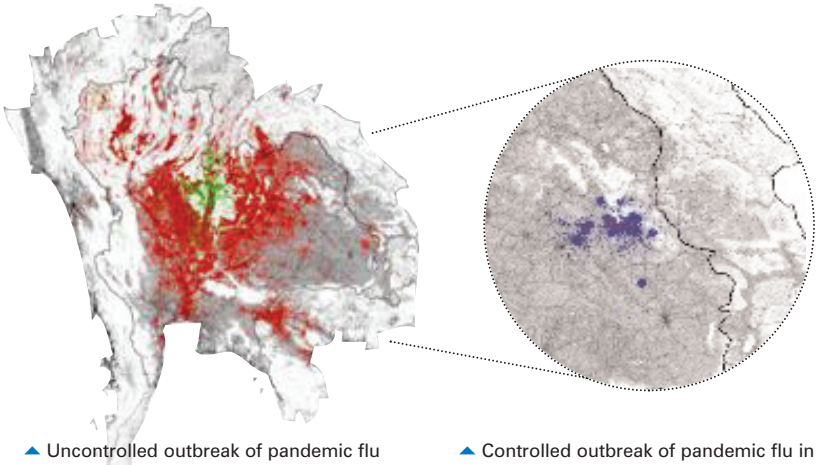
Since May 2004, a network of researchers has been building computational models of infectious disease outbreaks. The network is called MIDAS, for Models of Infectious Disease Agent Study. It receives about $7 million a year from the National Institute of General Medical Sciences (NIGMS), part of the National Institutes of Health.

Because the development and operation of the MIDAS models require a breadth of knowledge, the network draws together an interdisciplinary team of researchers with expertise in epidemiology, infectious diseases, computational biology, statistics, social sciences, computer sciences, and informatics.

WHAT DISEASES DOES MIDAS MODEL?

The MIDAS network focuses on emerging infectious diseases, whether they occur naturally or deliberately. The investigators work together to prioritize which infectious diseases will be modeled based on the potential impact of the models and the availability of information on which to build the models. Right now, the MIDAS researchers are focusing on pandemic influenza, a disease which many health officials predict could result from the H5N1 flu strain currently spreading among birds.

NIGMS (http://www.nigms.nih.gov), a component of the National Institutes of Health in the U.S. Department of Health and Human Services, supports basic biomedical research that is the foundation for advances in disease diagnosis, treatment, and prevention.



▲ Uncontrolled outbreak of pandemic flu in Thailand and surrounding areas. Red indicates new cases while green indicates areas where the epidemic has finished. Courtesy of Neil M. Ferguson, Imperial College in London.

▲ Controlled outbreak of pandemic flu in Thailand and surrounding areas. Blue indicates areas of infection where a combination of control measures has been implemented. Courtesy of Neil M. Ferguson, Imperial College in London.

WHAT DO THE MIDAS MODELS SHOW?

The initial MIDAS models, published in August 2005, focused on an outbreak of pandemic influenza in Southeast Asia, where the first bird flu-related cases appeared in people. The researchers asked: Is it possible to contain an outbreak at the source before the flu spreads globally and, if so, how?[1,2]

The researchers tested the effect of different intervention strategies, including vaccinating people before an outbreak with a somewhat effective vaccine, distributing antiviral medications, closing schools, and quarantining the neighborhoods of infected individuals. They found that a combination of measures, if implemented early and in a particular way, might contain the outbreak at the source.

The researchers are now studying what might happen if pandemic flu reached other parts of the world, specifically the United States. They're developing new computational models to reflect U.S. demographics and transportation patterns. With containment unlikely due to the connectedness of American society and the number of international travelers arriving every day, the researchers want to know what interventions could slow the spread of pandemic flu to ease demand on resources and allow more time for drug development and distribution. Results will be published spring 2006.

The MIDAS investigators continually critique each other's models to arrive at the most reliable conclusions.

WHO USES THE MIDAS RESULTS?

The results of the MIDAS network appear in peer-reviewed scientific journals for broad use. Government and public health officials can use the results to aid the development of policies related to infectious diseases. The MIDAS network coordinates and collaborates with federal and international agencies.

WHO LEADS THE MIDAS NETWORK?

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WANT TO KNOW MORE ABOUT MIDAS?

Visit http://www.nigms.nih.gov/Initiatives/MIDAS

NIGMS supports basic biomedical research that is the foundation for advances in the diagnosis, treatment, and prevention of disease. NIGMS is part of the National Institutes of Health, U.S. Department of Health and Human Services. To learn more about NIGMS, visit http://www.nigms.nih.gov.

[1] Science. 2005 Aug 12;309(5737):1083-7.
[2] Nature. 2005 Sept 8;437(7056):209-14.